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AUTOMATED IONOGRAM PROCESSING SHOWS SEASONAL VARIATIONS IN THE AURORA IONOSPHERE

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Automatic processing of digital ionograms from Goose Bay, Labrador (65° corrected geomagnetic latitude), permits fast evaluation of the diurnal and seasonal variations in the ionosphere. Ionogram data from 1980 are processed and displayed in ways that show the seasonal variations in foF2 and hminF. The effects of the mid-latitude trough that moves over the Goose Bay Station in the late evening are discussed.

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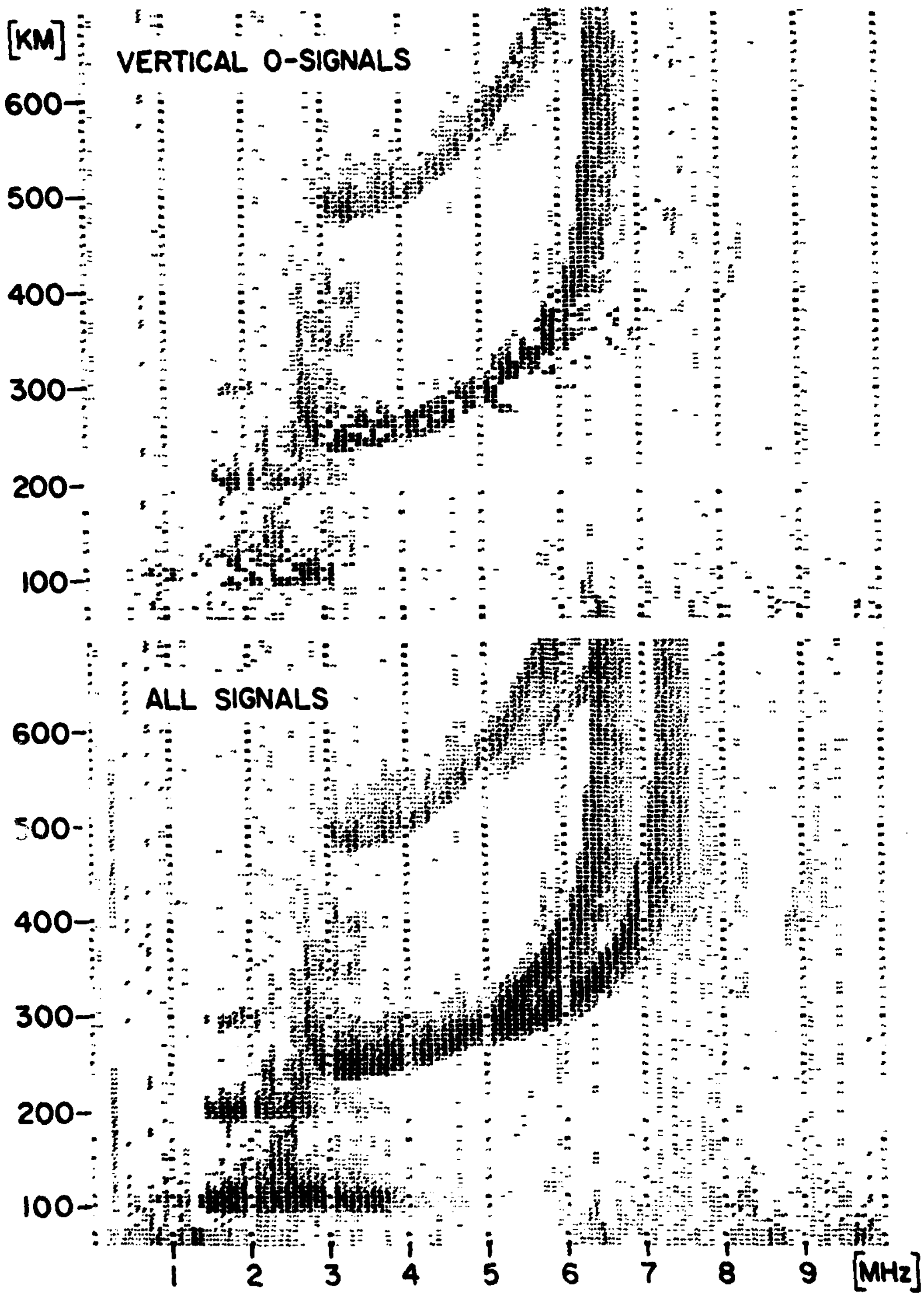
1.0 INTRODUCTION

Automatic processing of ionograms has become possible with the availability of advanced digital sounders. Since about 1970 when the first digital ionograms were routinely recorded on magnetic tape we have been developing software and hardware techniques for the extraction of the echo traces from the ionograms (Bibl et al, 1973). The initial concept was to decide immediately after transmission of each individual frequency which signals are echoes and only retain the amplitudes and heights of the identified echoes. For the archiving of routine ionogram observations and for the monitoring of ionospheric trends (Buchau et al, 1978), this method is acceptable if a sufficient number of echo points per frequency is allowed. But this approach is clearly inadequate for many scientific investigations in a disturbed ionosphere where the researchers want to see the complete range-versus-frequency display, i.e. the raw ionogram. Bibl and Reinisch (1978) described the on- or off-line printing of Digisonde ionograms using an optically weighted font to retain the digital resolution in the quasi-analog ionogram display (Figure 1). Such a display not only reveals all the nuances in the signal characteristics but it also establishes a continuous transition to the familiar analog ionograms.

A special objective is the automatic calculation of vertical electron density profiles. In this case, the vertical echo trace must be extracted and oblique, ducted and multiple echoes disregarded. During auroral night conditions the trace must be found within the spread F signals, relying on amplitude, Doppler and incidence angle informations that are contained in the digital ionograms. This is only possible by examining the ionogram in its entirety.

In this report we shortly describe the automatic ionogram scaling algorithm, developed on a main frame computer,



IONOGRAM WITH SOME SPREAD
GOOSE BAY 16 JUN 1980 05:20 AST

Figure 1

and its application to some 6,000 ionograms from Goose Bay, Labrador. The diurnal and seasonal variation of the critical frequency and the minimum virtual height of the F2 layer are used as indicators for the variability of the auroral F region.

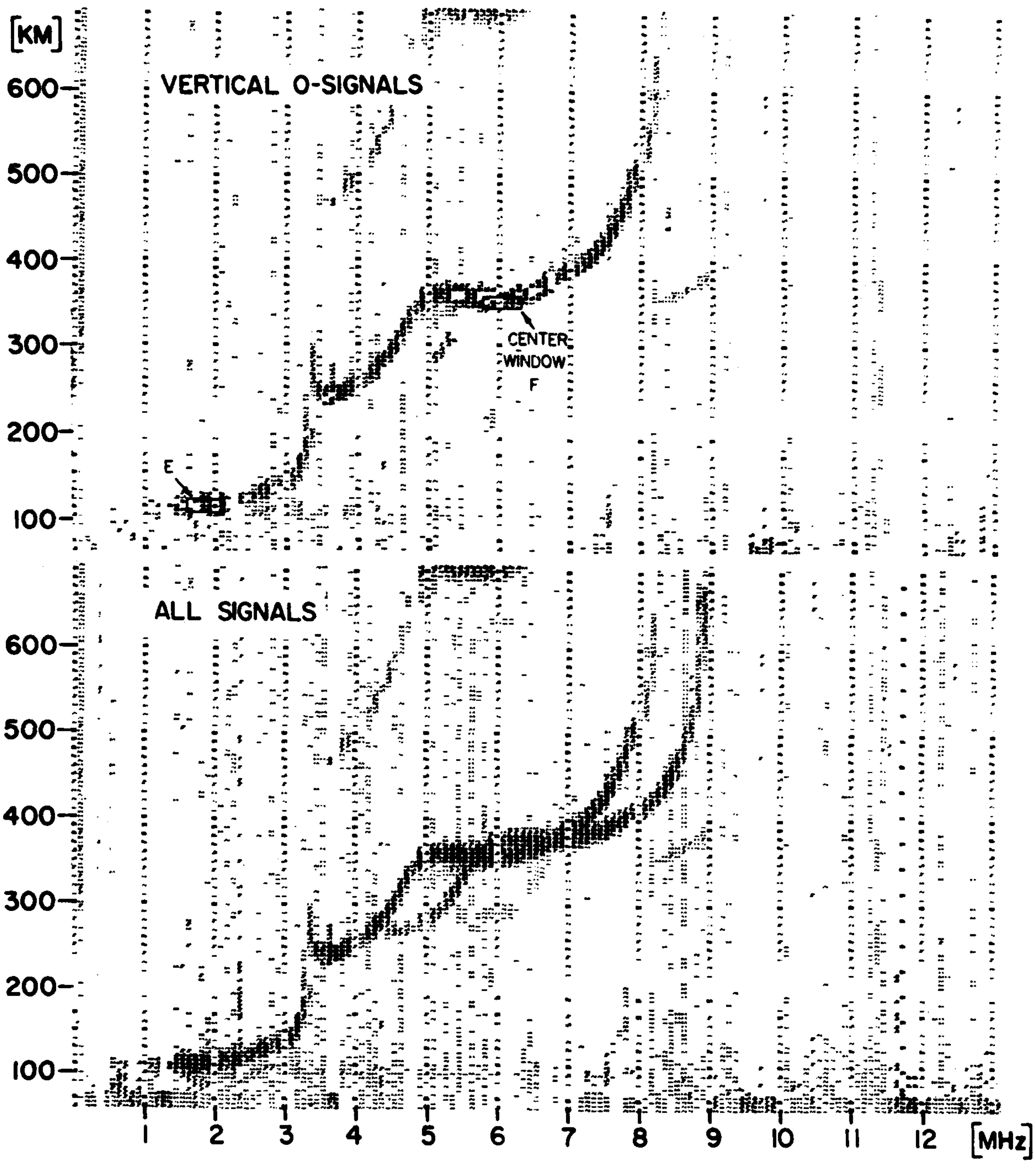
In 1971 the Air Force Geophysics Laboratory (AFGL) established the Goose Bay Ionospheric Observatory, equipping it with riometers, magnetometers, satellite receivers for total electron content measurements, and a Digisonde 128 for bottomside ionospheric sounding. Goose Bay is located at 53° geographic and 65° corrected geomagnetic latitude which means that the auroral oval (Feldstein and Starkov, 1967) reaches Goose Bay around local midnight during Q = 3 conditions (Gassmann, 1973), and correspondingly earlier during high magnetic activity. The mid-latitude F region trough, extending some 100-500 km equatorward from the southern edge of the oval is observed in the Goose Bay ionograms as a rapid decrease in foF2.

In 1978 the new Digisonde 128PS (Bibl and Reinisch, 1978) was installed at Goose Bay capable of measuring the signal polarization, incidence angles and Doppler shifts. The Geomonitor (Reinisch and Smith, 1976) currently performing the real-time ionogram scaling at Goose Bay does not yet take advantage of the additional information available. The new scaling algorithm presented here will eventually be implemented for the on-line processing.

2.0 AUTOMATIC SCALING OF MULTIPARAMETER IONOGRAMS

Automatic scaling of ionograms requires proper tagging of the signals with regard to polarization and incidence angle. To monitor the overhead ionosphere only vertical echoes should be considered. The tape-recorded vertical ionograms from Goose Bay contain for each frequency-range pixel the polarization, incidence angle and Doppler information in addition to the amplitude. An amplitude ionogram with mild spread F is shown at the bottom of Figure 1. The X-cusp emerges out of the O-trace at about 5 MHz, and the automatic separation and identification of the O and X trace from the amplitudes alone would be difficult. By printing only the vertical signals with O-polarization we obtained the ionogram in the upper half of Figure 1, which contains the data points the automatic scaling algorithm is using. Figure 2 shows a quiet daytime ionogram which is substantially simplified when the X-trace is removed (top of Figure 2). There are a number of bite-outs within the vertical O-trace which are caused by oblique or X-polarization echoes with higher amplitude than the vertical O-echo in these particular pixels. Some of these holes are replenished during the processing by checking the pixels surrounding the holes and filling in the median amplitude value.

The scaling algorithm starts the trace identification by finding the center windows, independently for E and F regions (see Figure 2). Allowing for reasonable slopes, the trace is then determined by sliding the window to the right (increasing frequency), and later to the left of the center position. This integrating window method is successful even under relatively disturbed conditions. Without going into details of the scaling algorithm, it should be mentioned that the resulting h'(f) trace may not be a smooth function suitable for use in a electron density profile inversion program



UNDISTURBED DAY IONOGRAM
GOOSE BAY 16 JUN 1980 17:20 AST

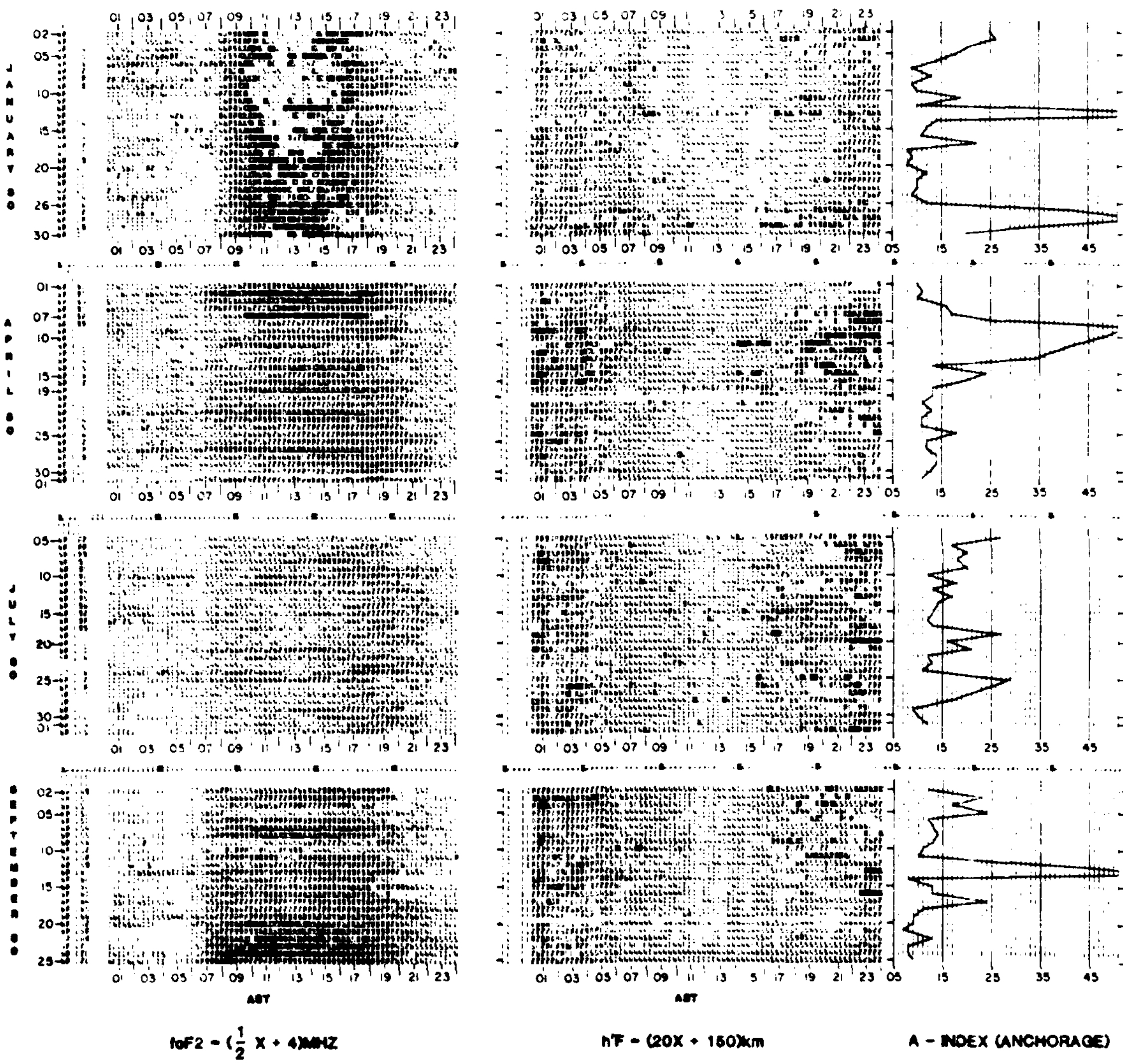
Figure 2

that is based on the standard lamination technique (see for example Doupnik and Schmerling, 1965). The trace data would have to be smoothed which is not a simple task because of the peaks in h' at foE and foF1. Huang and Reinisch (1981) successfully applied the profile-fitting method to automatically scaled topside ionograms. This method finds the monotonic electron density profile, described by a polynomial, that best reproduces the h'-traces in the least-squares sense.

3.0 VARIATION OF THE AURORAL F REGION

Four months of ionograms for January, April, July and September 1980 were processed with the new algorithm. With three ionograms per hour, or 72 per day, a total of about 6,000 ionograms were automatically scaled. We only discuss here two important F-region parameters, the F2 layer critical frequency foF2, and the minimum height of the F-layer h'F. The results for the four seasons are displayed in Figure 3, using the same optically weighted number font as used for the presentation of the ionograms. The left most panel shows foF2, the middle panel h'F, and the right panel the magnetic activity. The 72 daily readings are arranged in one line, with consecutive days following each other. Days with no data were simply deleted, namely January 25, April 5, 6, 17, 18 and July 19, 31, without serious effect on the evolving pattern.

January shows a well defined presunrise minimum in foF2 of about 3.5 MHz at 07 AST, and the morning increase in foF2 is very steady during the entire month. The sharp break in intensity indicates the 12 MHz line. During the first half of January, foF2 is larger than 12 MHz for three to four hours around local noon, occasionally exceeding 14 MHz. After January 20, foF2 stays below 12 MHz. During the first few days in April, the critical frequency stays just below 12 MHz. Starting with April 8, the foF2 peak values are about 8 MHz occurring in the late afternoon around 1800 AST. Values close to or above 10 MHz are reached on a few days: April 11, 14, 19, 22 and 27, centered around 14 AST. In July the maximum critical frequencies occur between 18 to 19 AST, reaching values of 8 MHz. The presunrise minimum of about 4.5 MHz occurs around 03 AST for April and July but it is not as sharply defined as in January. In September the pattern is changing again. The presunrise minimum of about 4 MHz is well defined around 04:30 AST, and toward the end of the month the peak of 11.5 MHz occurs around noon.



VARIATIONS IN AURORAL F-REGION

Figure 3

The gross features of the F-layer are fairly well described in this way. The main F-region trough is not always easy to see. The sharp decrease in foF2 occurring between 20 and 23 AST during the months of April and September seems to indicate either that the equatorward edge of the trough is moving over the station or that the trough is developing in the ionosphere over the station. In January and September the transition to night conditions occurs gradually and identification of the trough in the foF2 maps requires comparison with the individual ionograms.

The minimum virtual height of the F-region shows some very systematic patterns. As expected, the height reaches its maximum at night, displaying a large degree of variation, while the day values are much more consistent. In January, the heights level off shortly after sunrise to about 230 km and show little variation during the day. The apparent height minima at 09 and 16 AST are the result of a mistake in the scaling algorithm, which mistook the high cusp at foE as F-region echoes. We have subsequently eliminated this mistake in the program. In April, July and September the heights decrease rapidly at 05 to 06 AST to about 220 km and form a shallow minimum of 210 km around noon.

The night values for h'F vary considerably from day to day and the controlling function of the magnetic activity especially in the early night hours becomes evident when one compares the magnetic A-index with the height values. It is not our intention in this paper to analyze the F-layer height variations in terms of magnetic activity but rather to present a technique that makes it easy to relate different geophysical parameters. A good example is the magnetic storm starting on 7 April. The virtual height reaches values of 350 to 450 km at night, and on April 11 minimum heights of more than 400 km occur already at 16 AST. Similar good correlation exists in January and July, while the situation in September is less clear.

4.0 CONCLUSION

Automatic processing of ionograms provides the means for a fast and detailed survey of the diurnal and seasonal variation in the ionosphere. Our study of the auroral F-region at Goose Bay, Labrador, showed a fairly regular diurnal variation that gradually changed with season. Abrupt day-to-day changes in foF2 and h'F are clearly identified by the method, demonstrating its superiority over the use of monthly median curves. After having verified the accuracy and usefulness of our processing technique we can now apply it to an entire year of data to better understand the seasonal variations and the effects of magnetic storms. We can also apply our new electron density profile inversion algorithm to the automatically scaled Goose Bay ionogram data.

5.0 FUTURE PLANS

After having verified the reliable performance of the scaling algorithm we will now combine it with the adequate electron density profile inversion algorithm. The true height program which is currently being completed, applies the single polynomial profile-fitting method to the E- and F-region separately and allows for a valley between E and F. It is planned to test an 8086 microprocessor based Automatic Real Time Ionogram Scaler with True height conversion (ARTIST) on line by the end of 1982.

6.0 REFERENCES

Reinisch, Bodo W. and Sheryl Smith, "Geomonitor, Digital Real Time Processor for Geophysical Data," Final Report, AFGL-TR-76-0292, University of Lowell Center for Atmospheric Research (1976).

Bibl, K. and B. W. Reinisch, "The Universal Digital Ionosonde," Radio Science, 13, No. 13, pp. 519-530 (1978).

Buchau, J., W. N. Hall, B. W. Reinisch and S. Smith, "Remote Ionospheric Monitoring," Proceedings of the IES, paper 5-5 (1978).

Feldstein, Y. I. and G. V. Starkov, "Dynamics of Auroral Belt and Polar Geomagnetic Disturbances," Planet. Space Sci., 15, pp. 209-229 (1967).

Gassmann, G. J., "Analog Model 1972 of the Arctic Ionosphere," AFCRL-TR-73-0151, AF Survey in Geophysics No. 259 (1973).

Doupnik, J. R. and E. R. Schmerling, "The Reduction of Ionograms from the Bottomside and Topside," J.A.T.P., 27, pp. 917-941 (1965).

Huang, X. Q. and B. W. Reinisch, "Automatic Calculation of Electron Density Profiles from Digital Ionograms. Part 2. True Height Inversion of Topside Ionograms with the Profile-Fitting Method," Radio Science, 17, No. 4, pp. 837-844 (1982).